Driving Growth: How Clean Cars and Climate Policy Can Create Jobs

Report prepared for the Natural Resources Defense Council, United Auto Workers and Center for American Progress

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Preface

Reducing America's dependence on imported oil will not only enhance our national security, but it will create substantially more jobs than continuing on our current path of waste and unsustainable resource use. Reengineering the U.S. automobile fleet to use energy more efficiently will require new investments in advanced technology, increasing demand for skilled labor. Instead of presenting a threat to the auto industry, reigning in reliance on oil and cutting pollution from fossil fuels can demonstrably create jobs, accelerate innovation, and increase demand for advanced manufacturing.

Yet, while it is clear that increasing America's fuel economy can create more jobs, which nations will capture the economic benefits of this shift to a more fuel-efficient fleet, has yet to be determined. How Congress chooses to address comprehensive clean energy and climate legislation will strongly shape whether American workers enjoy the good jobs, competitive advantage, and sustained economic growth that will come with the move to a new clean energy economy.

This study offers two key insights on the nature of clean energy jobs in the automobile sector, each with profound implications for policy makers and the economy.

First, this paper documents that saving oil will create good jobs, not in the abstract, but directly by driving demand for specific additional manufactured components. The move to greater fuel economy means greater labor content per vehicle and higher employment across the fleet. This will include new investment in a host of incremental improvements to conventional gasoline powered internal combustion engines, from new controls for valves and timing, to variable speed transmissions and advanced electronics. It will also include entirely new systems like hybrid drive trains and advanced diesel engines.

Together these investments add up. By 2020 this analysis shows that, all things being equal, supplying the U.S. automobile market with more efficient cars could provide a net gain of over 190,000 new jobs from improvements to fuel economy alone.

The second finding is equally profound. While it is certain that the production of new technology will create demand for workers, *where* those jobs locate will be the product of policy choices. Of the over 190,000 jobs anticipated by 2020, the number of *domestic* jobs created could vary greatly. Fewer than 50,000 jobs might go to American workers, or, with different incentives, more than three times that number, as many as 150,000 U.S. workers, could find employment as a result of new investments in the engineering and production of the technology needed to improve fuel economy. It's up to us which path we take.

Many factors will shape where individual firms decide to produce fuel-efficient vehicles and their key components, and whether this new demand will be met through domestic sourcing or imports. But, it is clear that specific incentives can work to promote domestic production and drive new investment into existing plants and the skills of workers.

Strong comprehensive energy and climate legislation will ensure sustained reductions in oil use and carbon emissions. At the same time, it can capture economic growth through specific manufacturing conversion incentives funded through dedicated carbon allowance revenues. Legislation that sets a firm declining limit on global warming pollution is uniquely suited to this task for two reasons. First, it sends a critical message to markets and investors. Secondly, it provides a steady revenue source to drive long term, economic and environmental gains in the domestic auto sector and to assist in retooling assembly lines and retraining workers so that the United States continues to have a globally competitive auto industry that produces advanced clean vehicles. This integrated clean energy and jobs approach can expand opportunities for both U.S. firms and American workers, particularly in hard hit industrial states like Michigan, Indiana, and Ohio.

It is also worth noting that while the analysis undertaken in this paper shows substantial positive economic and jobs impacts from pursuing improved fuel economy, many additional benefits of energy independence do not even figure in this calculation. Therefore, as positive as this opportunity looks on paper, the real benefits go further.

Avoided fuel costs put real dollars back in the pockets of consumers, increasing consumption and economic benefits. At the same time, reducing demand for oil helps buffer price volatility, while decoupling the growth of the economy from rising energy imports reduces vulnerability to price spikes and supply disruptions. Further, by pursuing the high efficiency and low carbon emission technology path outlined in this report, U.S. auto makers will preserve access for American made cars to global markets, to serve the rapidly growing consumer demand for cleaner cars. As Americans use less oil to fuel our cars, we can also slow the flow of resources overseas to unstable and undemocratic nations, and invest instead in American jobs. By acting quickly, we can help to make the country less vulnerable to rising prices when global economic growth returns.

Clean energy manufacturing can drive the future prosperity of American workers if we creatively engage this opportunity. Our closest economic competitors in Asia and Europe are investing today in diversifying and expanding their manufacturing of clean energy technology. If the U.S. fails to make the same transition, we risk being left behind. However, climate legislation that includes manufacturing conversion incentives could help drive economic recovery and restore American leadership in the global automobile market and the global economy.

Which choice we make has yet to be determined. The future remains to be written.

— Bracken Hendricks
Senior Fellow
Center for American Progress

I. Economic Opportunity through Efficient Vehicles

The United States recently adopted standards to increase the fuel efficiency of the new vehicle fleet after more than two decades of inaction. The first measure, contained in the Energy Independence and Security Act of 2007, would have increased fleetwide fuel economy to at least 35 miles per gallon (mpg) by 2020. This standard was strengthened in May 2009 through a new program that established national harmonized fuel economy and greenhouse gas tailpipe standards. Under the latter program, the new passenger vehicle fleet will achieve, on average, 250 grams of CO_2 equivalent per mile by 2016. This is roughly equal to 35.5 mpg, requiring new vehicle fleet average fuel consumption to fall by 30 percent from 2012 to 2016.

Compliance with the regulations now adopted by the federal government will require a substantial deployment of new technology. The new technology represents additional content on each vehicle; content that will require more engineers and more workers to produce. This document identifies existing technologies that will enable automakers to meet the new standards, and uses illustrative combinations of technologies to make estimates of the *potential* for job creation in the auto industry and the industries that supply it.

While the media often equate fuel-efficiency gains with hybrids, wider adoption of more mundane clean-technology packages, many of which are already in use, will be critical. For instance, efficient gasoline engines and transmissions provide excellent fuel economy benefits at modest cost. Similarly, higher fleet fuel economy in Europe and Japan make it clear that clean diesel can play a large role.

To evaluate the opportunities to improve fuel efficiency and create clean energy auto sector jobs, the Natural Resources Defense Council (NRDC), the United Auto Workers (UAW), and Center for American Progress (CAP) commissioned The Planning Edge (TPE) and the Michigan Manufacturing Technology Center (MMTC) to model the 2014 U.S. new car and light truck market, considering North American-assembled vehicles, engines, and transmissions.

The production forecasts are based on a 2014 market size (U.S. sales) of 15.7 million, substantially higher than the current sub-10-million level, though well below the 1998–2006 average of 16.7 million. This analysis forecasts that 13.3 million cars and light trucks will be assembled in North America in both 2014 and 2020. Nine million of those will be produced in the United States. These levels of domestic and North American vehicle production are comparable to those of model year 2008. This similarity allows a straightforward comparison of auto sector jobs with and without the contributions of advanced vehicle technologies. The results suggest that clean vehicles can provide substantial employment benefits. The question left unanswered is where those jobs will be located—off shore or in the U.S.?

Our analysis conservatively assumes that gasoline and diesel prices will remain at today's level, in real terms. Thus, the mix of sales across traditional segments, i.e., small and large cars, and the various classes of light trucks, is held constant. By holding these factors constant we can ask the question: Other things equal, what ***existing fuel-saving technologies can be applied widely enough in the same-mix new vehicle fleet to meet the model year (MY) 2016 standard and to sustain a 4 percent annual improvement through MY 2020?***

In this report, TPE and MMTC evaluate the likely contribution of the commercially available technologies that firms will use to meet the 2016 standard and to make annual improvements beyond 2016. Toward this end, the report examines two benchmark years. First, it assesses clean technology deployment for MY 2014. This year is chosen because TPE's near-term forecast includes supplier information and automotive business forecasts extending through that time. Second, the report examines technology deployment for 2020. The 2020 technology forecast assumes that manufacturers make annual 4 percent improvements beyond their 2016 performance targets. Taken as a whole, this time frame represents the steady adoption of clean technology as manufacturers work toward, meet, and eventually exceed the existing targets.

Finally, the report assesses the economic benefits, focusing on job creation, associated with growing demand for fuel-saving technologies. Several findings are shown below:

- By 2014, the light-duty vehicle fleet modeled in this study would achieve 31.5 mpg. This will add about $848 to the manufacturing cost of each car and light truck assembled in North America. If this cost is applied across 13.3 million North American assemblies, $11.3 billion more in content will be added to North American-built vehicles.
- This will create 62,000 additional jobs, of which 20,000–54,000 will be in the United States. Just under 40 percent of these jobs will be in the auto and auto parts sector. The remaining 60 percent will be either in the broader manufacturing supply chain, including raw materials such as steel or intermediate goods (stamped, machined, molded, cast and forged parts), or in nonmanufacturing jobs elsewhere in the economy. Recaptured energy expenditures could provide further economic benefits, though those effects have not been modeled in this study.
- Achieving 40.2 mpg by MY 2020 would add an additional $1,152 to the manufacturing cost of each vehicle, for a total increase of $2,000 over 2008. The added production of $15.4 billion in vehicle content (a total of $26.6 billion over 2008) across North American assemblies will produce 191,000 jobs beyond 2008, of which 49,000–151,000 will be in the United States. Roughly 40 percent of the domestic jobs will be in the auto sector, while the balance will be in other industries such as services and the broader manufacturing supply chain.
- The wide variation in jobs created is due to the unknown potential for the United States to capture the production of these advanced vehicle technologies. The short record so far indicates that policies supporting the domestic manufacture of advanced technology vehicles can be successful. (For greater detail, refer to the section on Lithium Ion Takes Off in the United States.)

A UAW Local 909 worker assembles transmissions at the General Motors Powertrain plant in Warren, Michigan.

REBECCA COOK

Lithium Ion Takes Off in the United States

Lithium-ion batteries are a key enabling technology in the advancement of hybrid vehicles and are necessary for the market introduction of plug-in hybrids and electric vehicles. This technology was largely developed in the United States, but production is currently dominated by Asian-Pacific nations, especially Japan, China, and Korea. A 2006 study by the National Institute for Standards and Technology (NIST) makes clear that these nations use public policy to encourage the development of the industry, and especially the production of the battery cells themselves.[1]

These nations realize that if vehicle electrification emerges as the wave of the future, advanced battery production will be a core competency that allows them to maintain or develop from scratch a domestic automobile industry. Were the United States to fail that test, the long-term economic and security consequences could be harsh.

In 2007, the Energy Independence and Security Act established incentives for the domestic manufacturer of advanced batteries. The American Recovery and Reinvestment Act of 2009 subsequently funded these incentives. Earlier this year, the federal government announced the first wave of awards under these programs. The results are spectacular—48 projects have been announced to develop and deploy batteries and electric vehicle components in the United States.[2]

The bottom line is that the United States could emerge as a leading producer of lithium-ion batteries in less than five years because of government policies that lower the cost and risk of critical technology development. That is smart policy for jobs, energy security and carbon avoidance, and shows what well-structured government stimulus policies can achieve.

II. Methodology

This report illustrates the potentially large economic benefits of advanced-technology vehicle deployment under the right set of conditions: policies that encourage better fuel economy and domestic manufacturing. The sizable benefits underscore the federal government's critical role in introducing new technology through an appropriate policy combination of regulation and incentives for manufacturers. Such a combination will result in clean and efficient vehicles that are produced domestically. Toward the end of the report, we examine different degrees of economic benefit linked to the level of domestic manufacturing activity.

In the scenarios modeled here, MY 2014 vehicles will achieve an average (new definition—see note 3) CAFE rating of 31.5 mpg, as compared to 27 mpg in 2008. As previously mentioned, this will require an additional $848 per vehicle. If fuel economy reaches approximately 40.2 mpg in MY 2020, an additional $1,152 per unit will be required. This fuel economy estimate is chosen for simplicity and reflects a 4 percent annual performance improvement over the MY 2016 standard. It is roughly a continuation of the 2012–2016 fuel economy trajectory already in progress.

A determined federal initiative could push fuel economy beyond levels contemplated in this study. The Union of Concerned Scientists estimates that fleet average fuel economy could reach 42 mpg by 2020 if hybrid sales, already undergoing rapid adoption, reach 25 percent of the new vehicle market (rather than the 11 percent in our projection).[3] Federal policies that are successful in sufficiently lowering the cost of plug-in hybrids would enable even higher fuel economy. However, such programs are beyond the scope of this report. The analysis therefore makes the fuel economy assumptions listed in the table below.

Table 1. Forecast of Domestic and North American Vehicle Production

Metric	Model Year 2008	Model Year 2014	Model Year 2020
U.S. Car & Light Truck Production	9.7 million	9.3 million	9.3 million
North American Car & Light Truck Production	14 million[4]	13.3 million	13.3 million
Car mpg (new definition)[5]	31.5	36.5	44.1
Truck mpg (new definition)	22.2	24.8	34.1
Overall mpg (new definition)	26.7	31.5	40.2

Fuel economy improvements will utilize a broad range of technologies and benefit a diverse set of workers and businesses. TPE considered the expansion or first application of 15 technologies and components as changes and additions from current practice:

Hybrid and diesel vehicles:

- Switching from six- and some four-cylinder gasoline engines to four-cylinder diesel engines ("4D"). All 2014 and 2020 diesels are assumed to include after-treatment systems.
- Switching from eight- and some six-cylinder gasoline engines to six-cylinder diesel engines ("6D")
- Switching from eight-cylinder gasoline engines to eight-cylinder diesel engines ("8D")
- Switching from conventional gasoline-engine-only vehicles to full gas-electric or plug-in hybrids, in which an electric motor, new controls, regenerative braking, and a lithium-ion battery pack are added and a power-split device replaces the conventional transmission ("full hybrid")
- Switching from conventional gasoline-engine-only vehicles to so-called mild hybrids, with added power controls, an integrated starter-generator, and (particularly for Honda) additional features ("mild hybrid")

Four technologies that can be applied to gasoline and diesel engines, often at the same time:

- Direct injection, for both gasoline ("GDI") and diesel ("DDI") engines, in which traditional fuel injection is replaced by a more efficient system that improves the combustion of fuel. GDI and DDI are often referred to as "common rail."
- Turbocharging ("turbo"), in which additional power is generated from smaller-displacement engines, permitting them to replace larger-displacement engines
- Variable valve lift (VVL) and timing (VVT), in which new mechanical and electronic controls optimize the position of engine valves for a variety of driving situations
- Cylinder deactivation ("CD"), in which up to half of an engine's cylinders are shut down when power requirements drop (e.g., flat and downhill highway driving)

Three modified automatic transmissions:

- Switching from four- and five- to six-speed automatic transmissions ("A6")
- Switching from four- and five-speed to continuously variable transmissions ("CVT") in nonhybrids
- Switching from four- and five-speed to dual-clutch transmissions ("DCT")

Three features compatible with most vehicles (e.g., full hybrids already have Start-Stop):

- Switching to high-efficiency alternators ("HEA") in order to generate high levels of power at low speeds, thereby reducing the load on the engine and reducing the loss of energy
- Adding "Start-Stop," in which the gasoline or diesel engine turns off during extended stops (long red lights, traffic jams)
- Adding electric power steering ("EPS"), which is more compact than the traditional mechanical system and draws electric power from the engine only as needed

The table below shows the forecasted North American technology application rates (in thousands of vehicles). As modeled here, fuel economy of 40.2 mpg for 2020 requires that two technologies—high-efficiency alternators and electric power steering—not in use in 2008 become nearly universal, and that dual-clutch transmissions be applied to 30 percent of the U.S.-produced new vehicle fleet. The rest of the technologies are already in use, and nearly all will have at least 10 percent penetration by 2014.

Regarding V8 diesels, the technology application rates shown below only include vehicles weighing less than 8,500 pounds. Although heavier diesel vehicles are not addressed in this report, their engines are important because the U.S. facilities that produce them are prime locations for new six-cylinder diesels as well. Smaller diesel engines will share components with larger diesels, allowing these plants production efficiencies at lower volumes.

Application rates were achieved by examining every vehicle-engine-transmission combination and deciding which technologies, if any, to apply to each. Those decisions were informed by production logic, e.g., whether it would make sense to apply a technology to a very small number of engines. They were also based upon the particular manufacturers' strengths and their near- and midterm production plans. Thus, for example:

- The report assumes higher application rates of three technologies to engines with Ford's EcoBoost design, which combines GDI and turbo and soon will be matched primarily to dual-clutch transmissions.
- The report assumes faster dieselization of Chrysler vehicles because of Chrysler's connections to Fiat in North America and Europe. Similarly, it assumes faster dieselization of Honda vehicles, given their advanced designs in this area.

This report also favors applying technology to engines that have, or are slated to have, complementary features, e.g., adding GDI to engine families with VVL/VVT. Conversely, it is least likely to apply more expensive technologies to vehicle-engine-transmission combinations in the lowest-price vehicle tiers. Buyers of these vehicles are assumed to be the most price sensitive. Production volumes below reflect the number of vehicles assembled in North America that use each of the technologies. These advanced technology components could be produced inside or outside the United States. Production figures, reported in thousands, are for model years (typically October through September).

Table 2. Application of Technology in Thousands of Vehicles

Technology	2008 Actual	2014	2020	% of 2020 Assemblies	Change, 2008-2020
D4	69	339	709	5.34%	640
D6	144	297	329	2.48%	185
D8	130	509	534	4.02%	404
All Diesels	343	1145	1572	11.84%	1229
Full hybrid	85	665	1442	10.86%	1357
Mild hybrid	5	52	51	0.38%	46
GDI/DDI	668	1807	3577	26.94%	2909
Turbo	247	1132	2556	19.25%	2309
VVL/VVT	2139	4125	9426	70.98%	7287
CD	1126	1032	1003	7.55%	(123)
A6	1926	5944	5708	42.99%	3782
CVT, excluding hybrids	747	960	1201	9.05%	454
DCT	0	388	4173	31.43%	4173
HEA	0	8515	10460	78.78%	10460
Start-Stop, excluding hybrids	0	0	11633	87.61%	11633
EPS	41	1170	11428	86.07%	11387

TPE evaluated unit technology costs by averaging data from as many as four sources.[6] These estimates inform what might be called the "minimum efficient volume." From previous work, TPE defines this as roughly 400,000 units for components and 200,000 for complex assemblies such as diesel engines and hybrids.[7] Based on widely used engineering cost studies, this study estimates that unit cost would be substantially higher at lower volumes and up to 17 percent lower at higher volumes. The table below expresses the assumed cost-volume relationship. A technology with a unit cost of $500 at 400,000 units has a unit cost of about $700 at 100,000 units and about $415 at 2 million units. There are two exceptions to the rule that production volumes under 400,000 units incur cost penalties: for diesels and full hybrids, 200,000 units constitute an economic module. Unlike many of the discrete fuel-saving technologies, diesel engines and hybrids are more complex, multicomponent assemblies. For components, this analysis uses the following table to adjust unit cost for deviation in application volumes from the 400,000 *numeraire*.

Table 3. Deviation Cost Adjustments

Forecasted Volume	Percent of Numeraire	Example: $500 Technology
Less than 100,000	150	$750
100,000 – 249,999	130	$650
250,000 – 399,999	110	$550
400,000 - 499,999	100	$500
500,000 – 999,999	96	$480
1,000,000 – 1,999,999	89	$445
2,000,000 or more	83	$415

Unfortunately, one cannot determine technology costs by total production. For example, turbochargers are estimated to reach 1,132,000 units in 2014. However, this does not produce a unit cost of 90 percent of its *numeraire* value of $450. This is because not all of the forecasted 1,132,000 turbochargers will be built by one supplier in one facility. Since there is no precise way to determine how the volume will be divided, TPE divided production volumes more or less equally among three suppliers.[8] Thus the 1,132,000 turbos are really three packets of 377,000, so their unit cost is estimated at 110 percent of the $450 *numeraire*, or $495. The table below depicts the unit technology costs used in this study.

Table 4. Unit Cost and Fuel Saving Estimates

Technology	Gross Unit Cost at 400,000 Units	Content Displaced	Cost Displaced	Net Unit Cost at 400,000 Units	Illustrative Fuel Savings
D4	$3,400	Gas engine	$1,000	$2,400	25.0%
D6	$4,375	Gas engine	$1,200	$3,175	22.0%
D8	$5,700	Gas engine	$1,500	$4,200	20.0%
Full hybrid	$4,600	Various	$1,100	$3,500	45.0%
Mild hybrid	$1,500	Various	$500	$1,000	20.0%
GDI/DDI	$900	Conventional	$325	$575	16.8%
Turbo	$450			$450	8.4%
VVL/VVT	$305			$305	9.8%
CD	$193			$193	8.4%
A6	$1,020	A3, A4, A5	$900	$120	7.7%
CVT, excluding hybrids	$1,150	A3, A4, A5	$900	$250	8.4%
DCT	$1,400	A3, A4, A5, A6, CVT	$900	$500	13.0%
HEA	$140	Conventional	$35	$105	2.1%
Start-Stop, excluding hybrids	$600			$600	10.8%
EPS	$160			$160	2.8%

Data averaged from EPA (2008), MARTEC (2008), Meszler (2008) and Hammett (2004).

After determining technology application rates and the net unit costs, TPE and MMTC calculated the total cost of the added technologies across the 2014 and 2020 fleets. These figures, which reflect additional vehicle content, produce a substantial number of jobs. The costs are more than offset by avoided petroleum expenditures.

Economic estimates used in this report rely heavily on TPE's previous research.[9] Custom runs by Regional Economic Models, Inc. (REMI) were used to delve into the employment implications of domestic hybrids and advanced diesel production. Using the latest technical coefficient and intra-U.S. trade flow data then available, REMI associated each "packet" of 100,000 traditional U.S.-made vehicles with 21,270 U.S. jobs. REMI's estimates have proven highly accurate in the past.[10] The analysis then makes several downward adjustments to reflect declining labor intensity during subsequent years. First, it slightly reduces jobs per 100,000 vehicles to 20,175, accounting for manufacturing efficiency gains.[11] While production efficiency could be expected to cause larger reductions, those losses have been offset by increases in average vehicle content (e.g., airbags, navigation systems, etc.). Similarly, clean vehicle technologies illustrate an environmentally favorable way to balance productivity improvements with robust auto sector employment. However, as shown later, federal policy will play an important role in ensuring that both jobs and the manufacture of vehicle content are located in the United States.

Finally, TPE made a second conservative downward adjustment to reflect the recent shift toward transplant facilities. It is possible that these facilities will use lower North American content than their "Detroit Three" counterparts. To that extent, the U.S. jobs-per-100,000 figure was reduced a further 16 percent to about 17,000 for 2014 and 2020. Even under these assumptions, clean technologies deliver significantly more jobs than vehicles without the same features.

This conclusion is reached by applying labor intensities to the component cost analysis outlined above. For 2008, J.D. Power & Associates report a median new car and light truck pretax transaction price of $25,594. Based on prior analysis, TPE and MMTC estimate that 20 percent of this amount is attributable to brand marketing, transportation, dealer markup, warranty repair, interest, and other costs that apply to full vehicles but not to their components. The cost to design, manufacture, and test each vehicle averages about $20,000, which is a critical number to the analysis. TPE and MMTC assume that employment is proportional to cost. Thus, a fuel-saving technology that adds $500 to the cost of each vehicle is associated with 2.5 percent of the $20,000 vehicle cost. It is therefore associated with 2.5 percent of the 17,000 jobs per 100,000 units. If the technology is applied to 1 million vehicles, it would create 4,250 U.S. jobs.

III. Job Potential and Policy Implications

The methodology discussed above shows that efficient vehicle technologies will produce significant net employment benefits. The table below illustrates the jobs associated with TPE's 2014 and 2020 technology application rates. For 2014 and 2020, unit costs have been adjusted depending on the application rate of the new technology and total volume divided among three suppliers. For 2008, it is assumed that all technologies were produced at *numeraire* volumes, many of them outside of North America. Not all of the numbers in the chart below are U.S., or even North American jobs. They are total jobs, *anywhere in the world*, associated with the forecasted technology application on vehicles assembled in North America.

Table 5. Total Jobs Associated with Clean Vehicle Technologies

Technology	Net unit cost at forecasted volume	2008 Jobs	2014 Jobs	2020 Jobs
D4	$2,400	1761	6916	14464
D6	$3,175	4862	8015	8879
D8	$4,200	5807	18171	19062
Diesels		12430	33102	42405
Full hybrid	$3,500	3014	19784	42900
Mild hybrid	$1,000	46	443	434
GDI/DDI	$552 (2014), $518 (2020)	4085	8479	15750
Turbo	$495 (2014), $432 (2020)	1182	4763	9386
VVL/VVT	$275 (2014), $253 (2020)	6938	9642	20271
CD	$212	2311	1860	1807
A6	$107	2458	5406	5192
CVT, excluding hybrids	$275 (2014), $250 (2020)	1986	2244	2552
DCT	$650 (2014), $445 (2020)	0	2144	14720
HEA	$87	0	6297	7736
Start-Stop, excluding hybrids	N/A (2014), $498 (2020)	0	0	49242
EPS	$176 (2014), $133 (2020)	70	2380	12919
All		34520	96544	225314
Change from 2008			62024	190794

Potential for New Jobs to be Created at U.S. Facilities

Clearly, enhancing the value of cars and light trucks with fuel-saving technologies will result in a large number of additional jobs—62,000 more between 2008 and 2014 and another 128,000 in the subsequent six years. ***But there is no guarantee that the United States will capture all, or even most of these jobs.*** Both Europe and Japan have substantial leads in hybrids, diesels, DDI, and turbochargers. Most of these technologies have high value-to-weight ratios, making them eminently shippable. Nearly all of the key components in Nissan, Honda, Toyota, Ford, and Mercury hybrids sold in the United States are made in Japan.

Even if the major suppliers of these technologies conclude that future volumes justify North American manufacturing, it does not guarantee that such production will occur in the United States. In Europe, when the market for DDI/common rail for diesels spiked, Bosch built a huge new facility in low-wage Romania from which it supplies more than 80 percent of Europe's demand. The same could happen in North America, with Mexico in the role of Romania.

But there are also reasons why the technology needed to meet higher fuel economy standards could be produced in the United States. Most of North America's high-volume engine and transmission plants are located domestically rather than in Canada or Mexico. The same is true for nearly all advanced vehicle R&D and testing capacity. Many of these technologies "bolt on" to engines, most of which are assembled domestically. While Europe and Japan have a lead in some of them, their focus is on their application in small cars, which do not dominate the U.S. sales or production mix.

Thus, it is critical that federal government play a leading role in capturing for the United States the production of these technologies and the attendant economic output and employment. Comprehensive clean energy and climate legislation is the ideal policy tool because it provides support at the scale, predictability and duration needed to fund a meaningful economic and technological transition. Domestic manufacturing incentives funded through steady allowance revenues, could prove crucial in the choices firms make about where to locate production and our economic stake in these emerging trends. The range of possibilities is set out under three scenarios for U.S. production of fuel-saving technologies:

1. **Low:** U.S. facilities produce only 25 percent of the total technology value and receive 25 percent of the job benefits
2. **Mid:** U.S. facilities produce 50 percent of the total technology value and receive 50 percent of the job benefits
3. **High:** U.S. facilities produce 75 percent of the total technology value and receive 75 percent of the job benefits

There are, of course, exceptions to this rule:

- VVL/VVT, CD, and A6 are already substantially produced domestically, and there is no reason to think that the U.S. share of their production will decline.
- Except for some six-cylinders diesels in Mercedes and BMW models, six- and eight-cylinder diesels are unique to the North American market. This study assumes that 75 percent of these engines will be made in the United States, rather than in Mexico or Canada.
- Four-cylinder diesels may not be made in the United States until volumes grow more than TPE predicts they will through about 2016. But there is a good possibility that they will be made in at least some gasoline and (larger) diesel engine plants.

The table below shows the resulting forecast for U.S. jobs. As discussed above, it outlines the low, mid, and high scenarios that could result from different levels of federal commitment.

Table 6. U.S. Jobs Associated with Clean Vehicle Technologies

Technology	Estimated 2008 U.S. Jobs	2014 U.S. Jobs			U.S. 2020 Jobs		
		Low	**Mid**	**High**	**Low**	**Mid**	**High**
D4	0	0	3458	5187	0	7232	10848
D6	3174	6011	6011	6011	6659	6659	6659
D8	5807	13627	13627	13627	14297	14297	14297
Diesels	8981	19638	23096	24825	20956	28188	31804
Full hybrid	301	4946	9892	14838	10725	21450	32175
Mild hybrid	46	111	222	333	108	217	325
GDI/DDI	817	2125	4249	6374	3937	7875	11812
Turbo	473	1159	2318	3477	2346	4692	7038
VVL/VVT	3469	3469	4821	7231	5063	10135	15198
CD	2311	1860	1860	1860	1807	1807	1807
A6	2458	2458	2703	4054	1298	2596	3894
CVT, excluding hybrids	0	0	1122	1683	638	1276	1914
DCT	0	536	1072	1608	3680	7360	11040
HEA	0	1574	3149	4723	1934	3868	5802
Start-Stop, excluding hybrids	0	0	0	0	12310	24621	36931
EPS	0	595	1190	1785	3230	6460	9690
All Domestic Jobs	18856	38471	55694	72791	68032	120545	169430
Change from 2008		19615	36838	53935	49176	101689	150574
Domestic Jobs as a Percent of Total Jobs	59.1%	39.8%	57.7%	75.4%	30.2%	53.5%	75.2%

IV. Conclusion

Clearly, the development and production of clean energy technologies in the light-duty vehicle sector represents an enormous opportunity to maintain and create domestic employment. But the size and ultimate realization of that opportunity depends partly on the decisions of U.S. policymakers. Contingent on fuel economy rules, currency exchange rates, incentives for U.S. production (or the lack thereof), and automakers' and technology suppliers' production location decisions, the United States could gain fewer than 20,000 jobs from 2008 to 2014, or nearly 54,000. By 2020, the U.S. job gain relative to 2008 could be as little as 49,000 or more than 150,000. These figures also include jobs in the broader manufacturing supply chain, including raw materials and intermediate goods, as well as nonmanufacturing jobs created elsewhere in the economy.

Many of these jobs—especially those in diesels and in transmissions—could be expected to be concentrated in the three-state Michigan-Indiana-Ohio region. This region was home to 55 percent of engine and 85 percent of North American transmission production in 2008. Based on each state's 2008 employment shares, Michigan could expect to receive 21 percent of all jobs created by auto sector investment. Indiana could receive 5 percent, and Ohio could receive 7 percent. Applying these estimates to the findings above suggests that Michigan could gain as many as 32,000 jobs as a result of clean technology adoption (compared to 2008). Indiana could gain nearly 8,000, and Ohio could gain nearly 11,000 jobs. The remaining jobs would likely be much more broadly distributed across the United States. Locations of existing Delphi, Bosch, Denso, Aisin, Borg Warner, Siemens, GKN, and ZF facilities may be a useful, if incomplete, guide to the likely spatial distribution of fuel-saving technology production in the United States and the rest of North America.

Endnotes:

1 Ralph J. Brood, *Factors Affecting U.S. Production Decisions: Why Are There No Volume Lithium-Ion Battery Manufacturers in the United States*, National Institute of Standards and Technology, December 2006.

2 U.S. Department of Energy, "President Obama Announces $2.4 Billion in Grants to Accelerate the Manufacturing and Deployment of the Next Generation of U.S. Batteries and Electric Vehicles," http://www.energy.gov/news2009/7749.htm (November 24, 2009).

3 Jim Kliesch, *Setting the Standard: How Cost-Effective Technology Can Increase Vehicle Fuel Economy*, Union of Concerned Scientists, 2008.

4 The sales decline in calendar year 2008 resulted in large inventories and a huge drop in production in model year 2009. A more stable market assumed in 2014 and 2020 results in a more "normal" result where U.S. sales exceed North American production by a significant amount because of imports.

5 The new definition of cars and trucks go into effect in model year 2012. This requires that what would have been previously classified as trucks, namely two-wheel drive utilities under 6,000 pounds gross vehicle weight, be considered cars for fuel economy purposes.

6 EPA, *EPA Staff Technical Report: Cost and Effectiveness Estimates of Technologies Used to Reduce Light-duty Vehicle Carbon Dioxide Emissions*, March 2008; MARTEC, *Variable Costs of Fuel Economy Technologies*, study prepared for The Alliance of Automobile Manufacturers, as amended December 12, 2008; Dan Meszler, Meszler Engineering Services (MES), unpublished report, fall 2008; Patrick Hammett et al., *Fuel-Saving Technologies and Facility Conversion: Costs, Benefits, and Incentives*, study prepared for the National Commission on Energy Policy and Michigan Environmental Council, November 2004.

7 Hammett et al., 2004.

8 This assumption, while apparently arbitrary, is surprisingly robust. In component system after component system, the rule that three competitors share the vast majority of the market seems to hold. In North America, Bosch, Delphi, and Siemens split many powertrain components. Delphi, Denso, and Visteon divide much of the HVAC market, though they must share some components with Valeo. Aisin, ZF, and American Axle divide the market for many axle and drivetrain components. Borg Warner, GKN, and Magna compete in many chassis and powertrain areas. Magna, Ogihara, and Budd dominate outsourced frames, subframes, and body panels. In Europe and Japan, such Tier 1 triads are also common.

9 Hammett et al., 2004

10 At that time, about 45 percent of these jobs were in auto and auto parts, and the other 55 percent in other sectors. Thus, in a year such as 2005 in which 11.5 million light-duty vehicles were assembled in the United States, REMI would have forecasted 2,446,000 U.S. jobs, including about 1,100,000 in auto and auto parts, almost exactly the figure (1,096,700) reported by the Bureau of Labor Statistics.

11 By 2008, the Bureau of Labor Statistics estimate for U.S. motor vehicle and parts jobs had declined to 877,000. The REMI method would have therefore estimated 1,950,000 total U.S. jobs of which 45 percent would have been in the auto sector (this number is now closer to 40 percent). Dividing by 21,270 U.S. jobs per 100,000 vehicles would have predicted production of 9,170,000 units; in fact, 9,666,000 were produced. Thus the 21,270-per-100,000 ratio had declined modestly to about 20,175.

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